FLAX,

ITS TREATMENT, AGRICULTURAL AND TECHNICAL.

Flax belongs to the order Lineæ in the Natural System, which is equivalent to the order Pentandria Pentagynia in the Linnæan, a small order containing, according to Lindley,* 3 genera and 90 species, which are met with scattered irregularly over the greater part of the world. Europe, North Africa, and North and South America seem to be its principal stations; individual members, however, are found in India, New Zealand, Australia, and other countries. Its native country appears to be a matter of question amongst botanists, as it is found growing wild in most countries where the physical conditions are suited to its cultivation. The general opinion, however, inclines towards ascribing it to the East. Be that as it may, this disposition to suit itself to such a vast range of soils and climates is of infinite

* Vegetable Kingdom, p. 485.

importance to man, as it enables him to avail himself of the advantages resulting from its cultivation to a far greater extent than he otherwise would be able to do. The botanical characters of the order are well marked, and render it easily distinguishable from all others. It possesses 4, or more commonly 5, sepals; the petals are always equal in number with the sepals; the stamens are also equal in number, and alternate with them; it has 5 stigmas and an ovarium with 10 divisions, or rather 5 perfect cells, which are separated again by an imperfect partition, extending from its outer wall. In each of these cell is found a single seed of a flattened oval shape, and of a more or less dark brown color—mucilaginous to the taste, and containing a large proportion of a brownish yellow oil, known as linseed oil. This oil is readily obtained by pressure from the seed, the residuum being the well-known feeding substance termed linseed cake.

The members of this order, generally, are remarkable for the tenacity of their fibres, the elegance of their shapes, the beauty of their flowers, which are blue, red, or white*, and the emollient and demulcent properties of their seeds. All are harmless,

* M. Brogniart considers that white varieties often exhibit a marked difference in the coloring of the leaves, and suggests that a modification may also exist in the tissues of the stems. M. L. Vilmorin is at present experimenting upon the cultivation of white varieties of flax.

some possessing slight medicinal action, in others even this is absent. Of these we may cite the Linum Catharticum, a very common weed, whose leaves contain properties of a purgative character, and the L. selaginoides, which is accounted in South America of great use, both as a mild aperient and as a tonic. Probably these properties pervade the whole order, but have not been remarked in the cultivated flax. Several of its members are plentifully met with in this country as weeds: the Linum Catharticum is very common on poor lands in Europe, though I believe it is not found on the American continent; the L. perenne (or Siberian flax), usually on formations containing chalk or lime; the L. usitatissimum on cultivated soils; and more rarely the L. angustifolium, which is met with on sandy and barren pastures, principally near the sea; while the Radiola is well known to all botanists as being met with in moist and boggy places.

Although there are many kinds of flax known to botanists as possessing fibres suitable for textile purposes, the L. usitatissimum appears to be the only one which has been employed in cultivation. Of this Dr. Lindley tells us there are two very different forms,* namely,—1. The L. humile or crepitans (the

So far, he considers the fibre to be of a coarser quality.—*Annales de l'Agriculture Française. Fev.* 1853.

* Encyclop. of Agric.——*Blackie and Co. London.*

Springlein or Klanglein of the Germans), a plant somewhat shorter and more inclined to branch than the other, and possessing larger capsules, twice as long as the calyx, which burst with considerable elasticity when ripe; its seeds, too, are both larger and of a paler color. 2. The L. usitatissimum, or true winter flax (Winterlein of the Germans), which has smaller capsules, scarcely longer than the calyx, not bursting with elasticity, but firmly retaining their seeds, which are of a dark brown color. These distinctions do not seem to be very well understood by the growers of flax, though they certainly are of some practical importance.

In the market we frequently meet with this full-bodied light-colored seed, usually the produce of the E. Indies, and it is generally considered to be the produce of flax harvested before the straw was quite ripe; whereas it is the mature produce of a different variety, suitable for spring sowing, and probably having a more rapid growth than the L. usitatissimum or winter flax. In the foreign department of the Great Exhibition in 1851 samples of both were seen in several places. In Austria and Northern Europe, where the winters are severe and the snow lies too long on the ground to admit of early tillage in the spring, the Winterlein is extensively used and sown in the autumn; the summer season being too short and too

hot to admit of the successful cultivation of the Spring-lein. The general custom in Europe as in this country is to sow in the spring, though no doubt in some of the northern districts, where the ground cannot be got ready sufficiently early in the spring, flax could be advantageously cultivated if sown in the previous autumn.

The important services which flax has rendered to man have secured for it a record from the earliest times. In the Bible we find frequent mention made of it both as flax and in its manufactured state as linen; and on various Egyptian monuments the plant and the preparation of its fibres are represented.

In the Book of Exodus* it is noted as one of the principal crops grown in Egypt. Being one of the chief sources whence the Egyptians derived articles of comfort and luxury, it was selected by the Almighty for destruction when he sent the plague of hail as a judgment on that people. From the Book of Joshua† we find that flax was cultivated in Palestine, where it is stated that Rahab used flax to hide the spies sent by Joshua to examine Jericho.

In the history of Samson,‡ also, reference is made to flax as being a well-known crop. Many allusions are made to it in its prepared and manufactured

* Ex. ix., v. 31, 32. † Josh. ii., v. 6. ‡ Judges xv., v. 14.

state, both in the Old and in the New Testaments,* all of which refer to the same plant we now term flax, and which is the same as that known by the Hebrew name "Pishtah," and by the Greek name "Linon."

We have also ample records of its cultivation in the days of Greece and Rome. Columella† speaks of it as a hurtful crop, which exhausts the land, and which he says "should not be grown unless there is reason to expect a very great crop, and one is tempted by a very great price." Virgil‡ joins it with oats and poppies, and says "that all these exhaust the soil." Palladius§ expresses the same opinion. Pliny,** while condemning it as a crop, moralizes over it and asks, "what greater miracle than that there should be a plant which makes Egypt approach nearer to Italy; that there should grow from so small a seed, and upon so slender and short a stalk, that which, as it were, carries the globe itself to and fro." By this we must infer that its use both in the shape of ropes and sailcloth was well known; and in the succeeding chapters we are informed that many na-

* Prov. xxxi., v. 13–19; Is. xix., v. 9; 1 Sam. ii., v. 18; 2 Sam. vi., v. 14; Jer. xiii., v. 1; 1 Kings, x., v. 28; 2 Chron. i., v 16; Ezek. xiv., v. 3; Hos. ii., v. 5–9, and other places.

† Columella, lib. ii., cap. x.

‡ Georg., lib. i., v. 77. "Urit enim lini campum seges, urit avenæ."

§ Palladius, lib. xi., cap. ii.

** Pliny, Nat. Hist., lib. xix, procem.

tions used it when woven into linen as wearing apparel. Pliny is the only author who enters minutely into the details, both of its cultivation and subsequent preparation. He speaks chiefly of spring-sown flax. According to the other authors flax was sown usually in the autumn, in the months of October and November, when 8 *modii** of seed were sown upon the *jugerum*, whereas 10 were required for the spring sown, the land having been previously manured. The harvesting and steeping appear to have been carried on much the same as in later times; the scutching was performed by beating the steeped straw upon a stone with a peculiar mallet, and then drawing it through iron heckles. The tow was of little use except as wicks for candles. The "boon," or "shove," was used as fuel, and the cleaned fibre was bleached by being watered and exposed in the ordinary manner. He describes Spanish flax as being of very fine quality; and mentions another sort, which was cultivated in Campania, whose fibres were so fine and so tough that nets were made of them to entangle wild boars, and so hard as to resist even the stroke of a sword:—"I have seen," he says, "these snares of such fineness as to pass with the ropes at the upper and under side through the ring of a man's fin-

* The Roman modus was about the same as the English peck. The jugerum was equal to ·618 of an acre.

ger; one man being able to carry as many of them as would encircle the hunting ground. Nor is this the most extraordinary part, for each strand of them consisted of 150 threads." He relates also that, in the temple of Minerva in Rhodes, the breastplate of Amasis, a King of Egypt, was found made of this net, each strand consisting of 365 threads. This was taken by the Consul Mutianus to Rome, where it was exhibited at the time Pliny wrote, as a specimen both of fineness and strength of fibre, and also of skill in spinning and twisting yarn. Certainly modern times have nothing to compare with it.

The absence of all agricultural records after the fall of the Roman Empire leaves a blank in its history until towards the end of the 12th century, when we gather, from papers of that period, that flax was in considerable cultivation in Great Britain, and also in various parts of the continent of Europe. As that country became more settled, and general civilization advanced, the use of linen became more general; and we find that, in 1532 (Hen. VIII.), an Act of Parliament was passed, requiring that every person occupying land fit for tillage should, for each quantity of 60 acres, sow at least 1 rood of it in flax each year. This quantity was increased to an acre in 1562 (Elizabeth) under pain of a penalty. In 1691 (William and Mary), with a view to encourage its cultivation as much as possible, an Act was passed fixing the

tithe on flax at only 4*s*. per acre. In 1713 (Anne 12, cap. 16) a bounty of 1*d*. per ell was allowed on the exportation of home-made sailcloth; and in 1806 (George III. 46, cap. 46) a bounty was offered for the importation of flax and hemp from the American Colonies.

These references tend to show that the growth of flax has occupied public attention on both sides of the Atlantic, and would lead us to infer that, although probably the proportion grown formerly was superior to that of late years, still the demand was always greater than the supply.

In England the ratio of difference is increasing rapidly every year, and the question of supply becomes every year of increasing importance to her. The extension of flax cultivation from various causes, has not been so great as the extension of flax consumption, and she is obliged to rely upon the production of other countries for an article for the growth of which her own temperate climate is so peculiarly adapted. By recent returns published by the Board of Trade, it will be seen that the import of textile fibres (flax and hemp) into Great Britain in 1851, amounted to no less than 2,495,672 cwt. It is to this point that I wish particularly to call your attention, as I find on making inquiries as to the agricultural productions of the United States, that

although flax enters largely into the cultivation of some of the West and South-western states, the seed is the only marketable return which the farmer gets, the straw being entirely neglected. Probably some 200,000 to 300,000 acres have been cultivated this year, producing according to the best estimates I could obtain, between 8 and 10 bushels of seed per acre; which, judging from the relative yield in Europe, would give about 1 ton of straw to the acre, or a gross amount of from 200,000 to 300,000 tons.

These amounts, though large, are nothing compared with the immense productive capabilities of those fertile districts. The same obstacles, however, appear to limit them here, as have so prejudicially retarded the extension of flax cultivation in Great Britain. These are "the general opinion that flax is an exhausting crop," and "the difficulty of finding a market for it when produced." As regards the first, thanks to the important advances which agricultural chemistry has been making, the question has been entirely set at rest by the true explanations which science places in our hands for them. For the principles involved, I *must* refer you to some of those excellent treatises which have appeared from time to time, both in this country and my own;* at the same time, I would give

* See also papers on "Analysis of Ashes of Plants," by May. —R. A. S. J.

as a practical illustration some experiments which were made a short time since, (1852), &c.

Some experiments were made a short time since, by Dr. Hodges, for the purpose of ascertaining the relative proportions of the produce of flax, and also the distribution of the inorganic matter in them. The flax employed had been steeped in the ordinary way, and was found to contain 1.73 of ash. Of this air-dried straw 4000lbs. weight were taken, which produced—

Of dressed fibre	500 lbs.
fine tow	132
coarse tow	192
Of fibre in all . .	824 lbs.

These products contained—

In the dressed flax	4·48 lbs. of ash.	
fine tow	2·08	,,
coarse tow	2·56	,,
Or in the whole of the fibre . .	9·12 lbs. of inorganic matter;	

so that 59·08 lbs., which the crop had withdrawn from the soil, remained in the useless portions, while only 9·12 lbs. were carried off in the dressed fibre. If we compare these results with those obtained from the analysis of an acre of wheat, for instance, we shall see that while the flax fibre takes away with it 9·12 lbs. of inorganic matter, the wheat crop, grain and straw together abstract about 365 lbs. from the soil.

The consideration of the second is so mixed up with the question of a good process for preparing the fibre, that it will be better to leave it until I have made you acquainted with what has been done, and is still doing, towards that most desirable end. This concerns the grower of flax directly, as upon this hinges the security of a constant market for his raw produce; for it rarely happens that a farmer can combine successfully the two distinct branches of producer and manufacturer.

In this country, where labor is so costly and so difficult to obtain, it would be quite impossible to adopt on a large scale the hand-pulling process of Europe. It is not difficult to foresee that if flax growing for textile purposes is to be carried out as a system, the same mechanical ingenuity which has already been taxed so largely for the farmer's benefit, will again come to his aid, and will produce a substitute for hand-labor in the shape of a machine, which will do the work as efficiently and at a far less cost than by manual labor. The attempt has already been made by more than one skillful mechanic. Even if no satisfactory machine for pulling presents itself, the *mowing* machines, of which several excellent ones are to be found, would answer the purpose sufficiently well, as on a level surface they would sever the plant immediately above the crown of the root where

the fibres commence. In all cases it is desirable that the cut flax be loosely tied up in small sheaves, and set up in the usual manner—not left lying on the ground, by which great injury is sustained.

Flax, fortunately, has a very wide range of soils :† sands, sandy loams, light and heavy clays, gravels, chalk, marls, alluvial soils, peat and reclaimed marsh lands are all seen, under ordinary circumstances, to produce a crop. The sandy loams and the alluvial soils, natural as well as artificial (warp lands), however, appear to be the best suited to its cultivation. In Ireland large crops are obtained on peat bogs, lands with a clay substratum. The plant needs an open soil, through which the water may freely percolate, as its roots are of a fibrous nature, and extend laterally and vertically to a considerable distance (2 or 3 feet). All the conditions required

†	Irish.			Belgian.			
	1	2	3	4	5	6	7
Silica	73·72	69·41	64·93	92·78	87·04	91·8	86·47
Alumina	6·65	5·77	8 97	1·11	1·52	1·22	1·57
Water	7·57	11·48	8 62	2·03	3·8	1 85	2·92
Organic Matter	4·86	6·67	9·41	2·74	4·48	3·45	5·78
	Londonderry and Tyrone.			Dussel, near Antwerp,	Courtrai.	Lakeren.	Ypres.

Prize Essay on Flax, by James M'Adam, jun.—R.A.S. Journal, vol. viii.

for its successful cultivation are, that the soil be deep, in good heart and in good tilth, well drained and free from weeds; if these exist we may, under ordinary circumstances, expect a good crop. Owing to the rapid growth of the plant, and the consequent shortness of time it occupies the land, it offers many opportunities to the grower, and admits of more changes in the rotation than most of the other farm crops. These rotations vary in every country, and indeed in almost every locality, and must necessarily be influenced materially by the soil, the climate, and the general cultivation in relation to the markets of the district. As these rotations are subject to so many modifications, it is unnecessary to occupy your time with describing them now.* I would only mention that, under ordinary circumstances, it is found that the crop succeeds best after corn, or upon recently broken up ground; and that the crop is not generally so remunerative when it follows turnips, potatoes, or other root crops. The large quantity of organic matter usually applied to such crops has a tendency to make the flax grow rank; and although a large crop is frequently obtained, the quality is not so good, and the plant is more liable to sustain injury both from wind and wet at the time approaching its maturity.

* See Essay on Flax.—R.A.S. Journal, vol. viii.

The mode of cultivation is too well known to need more than a passing observation. The condition and tilth of the soil must be secured,* about two bushels of *cleaned* seed to the acre should be sown broadcast by the hand or by the broadcast barrow; it should then be covered in by a pair of fine harrows, and a light roller run over it completes the operation. The month of April is the usual time for getting in the seed, but I am much inclined to think that flax might be grown advantageously in many late districts by being sown in the autumn.

After being properly got in, the only care it requires is *weeding*. *It is important that this be done in a careful and effective manner, as the value of the crop depends materially upon its cleanness.* The harvest operations differ slightly from the usual crops; the proper time is determined by the color of the straw and of the seed. The straw should have assumed a yellow color immediately under the branches; and the seed should, on cutting open the capsule, be of a pale brown color. Flax is always pulled up by the roots; these handfuls are usually laid across each other, and subsequently bound up into small sheaves; these are set up in circular stooks, the

* Ploughing up the land intended for flax before the winter frosts set in would be advantageous; both by destroying some of the annual weeds, and by securing a finer division of the soil.

butts of each being spread out as much as possible, to allow the air to have free access to them; there they remain until sufficiently dried; they are then either stacked in the field or at the homestead; or the seed is separated at once, and then merely the stem or straw stacked. Many different modes both of stacking and of separating the seeds exist; probably the cheapest and most efficient is to pass the straw through plain rollers, which crush the capsule, and let the straw pass through uninjured. The seed is separated from the capsule or "boll" by winnowing, and the straw remains to be stacked in the usual way. Under favorable circumstances we may expect an average crop to produce from 30 to 40 cwts. of straw and 16 bushels of seed to the acre.

The crop now becomes divided: the one portion is directly serviceable to the farmer as a valuable feeding substance; or as a marketable produce in great demand; the other, the straw, is comparatively of little value until it has undergone certain processes by which its character is entirely changed. These require a series of operations quite different from those of the farm, and, in fact, constitute a distinct branch of the flax industry, intermediate between the grower of the straw and the consumer of its prepared fibre, the spinner. This division of labor greatly benefits the grower, as supplying a constant

market for an article which a well-organized establishment can dispose of far more beneficially than he could do at home, with imperfect means, and too often, imperfect knowledge.

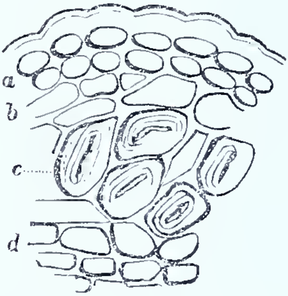
Before describing these various processes let us consider their object, and the nature or composition of the substance they have to treat. The object may be given in a few words,—the separation of the fibrous from the other portions of the straw. If we take a portion of straw, break it, and carefully examine it, it will be found to consist of three distinct parts:—the centre is occupied by a substance composed of a cellular tissue, in appearance like wood; this is usually called the "shove" or "boon;" round this is a tubular sheath composed of bundles of long and tough fibres, cohering firmly together, the whole structure being cemented together by an azotized compound, and enveloped by a thin and delicate bark and skin. The structural arrangement of the stem of the flax plant is beautifully described by Schacht, from whose admirable treatise, Die Pflanzenzelle,* the accompanying plate has been obtained. If a piece of the dried straw be rubbed between the fingers, the bark is immediately removed, and the fibrous portions are more or less readily detached

* Physiologische Botanik, Die Pflanzenzelle, von Dr. Schacht. Berlin, 1852.

Sections of Flax, Straw, and Fibre.

200/1

1

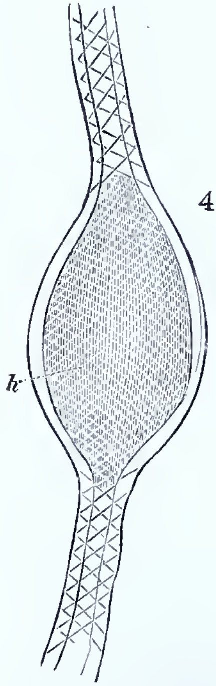


1. Transverse Section of Straw.

a. Epidermis. *c.* Fibres.
b. Bark. *d.* Shove, or Woody Centre.

400/1

4



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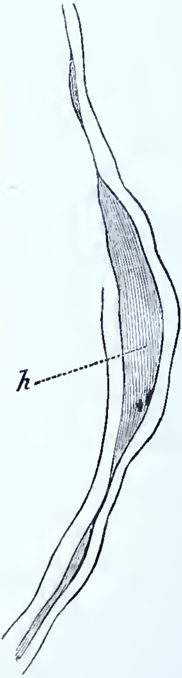

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2

2, 3, and 4. Longitudinal Sections of Fibres—*h*, *h*, *h*, Cavities.
2 and 3. Ordinary Cavities.
4. Rarer kind.

from the woody centre. These fibrous portions being composed of bundles of very delicate filaments, may be split up into almost any degree of fineness, according to the process adopted. Now these various processes differ very much, both in their principles and in their mode of separating the fibre from the other portions of the plant.

They may, however, be all classed under two heads,—the *mechanical*, in which the operations are conducted in a *dry* state; and the *chemical*, in which *moisture* is more or less necessary. In the first the object is obtained by the various parts being mechanically separated from each other; in the latter the plant itself is disintegrated, either by the action of fermentation, which destroys, or of some solvent, which abstracts, the cementing matter by which its parts are held together.

Of the first but little need be said, as, except for rough goods not requiring to be bleached, as canvas, rick-covers, rope-yarn, &c., it could not at present be advantageously used; however, as it costs as much to steep bad straw as good, and the expenses in some such cases exceed the value of the produce, it would appear that the dry or mechanical process may be most beneficially tried when the raw material is of inferior quality,—where there is a difficulty in steeping it properly,—or where coarse fibre

only is required. Several modes have, from time to time, been devised for effecting this mechanical separation, of which the following are those most entitled to notice.

In 1812, Lee took out a patent for this purpose, to which Parliament accorded a peculiar privilege, that the time for specification should be extended from 6 months to 7 years. This was shortly taken up by the Irish Linen Board, who expended 6000*l*. in their endeavors to introduce it in the flax districts : one of the machines is still preserved in the White Linen Hall at Belfast. Before the time for specification arrived, another patent was taken out by Hill and Bundy, in 1817, and more recently those by Donlan and others have been brought before the public. On the Continent the same attempt has been made, and with like success. Some few years back M. Christian, ancien Directeur du Conservatoire des Arts et Métiers, at Paris, devised a mechanical process for the separation of the fibre, which appeared to answer well at first, but was afterwards gradually abandoned.

Even in the event of a successful result in the separation, the goods thus manufactured from the fibre are always liable to be injured by moisture, or any other condition that would act upon the azotized substance, which would still remain enveloping and cementing the fibres together.

The second, the *chemical* or *wet process*, must be considered under three different heads:—

The first, when the separation is effected by *simple fermentation*, known as "steeping."

The second, where it is due to the abstraction of the azotized extractive compound, by the agency of *chemical solvents.*

The third, where *simply water*, either heated or in the shape of steam, is used. In the first, a destructive fermentation is carried on at the expense of the extractive matter of the plant, and offensive and noxious gases are generated; in the second, this matter is removed by the aid of chemical ingredients, which are costly, and render it of little value; while by the third the whole of the substance abstracted is preserved in a state immediately available, and valuable as a feeding substance. The process of steeping is carried on differently in different districts; the oldest is probably that called "dew-retting," in which the straw is spread out on the grass and carefully watered, so as to supply sufficient moisture to support the action of fermentation in the tissues of the plant. This is a very tedious process, still adopted in some parts of the Continent, and rarely to be met with in Ireland, requiring several weeks for completion, and in dry seasons not practicable at all. The usual method is to immerse the straw, either in tanks or pits constructed

for the purpose, or in slowly-running streams. Suitable arrangements are made for effecting this:—In Belgium, where it forms a distinct branch of the trade, wooden crates are made, which are filled with the flax, and then carried into the stream and weighted down; in Ireland and other places where pits or tanks are used, the flax is placed in loose bundles, and kept down by means of planks, or other convenient materials. In a few days a scum appears on the surface of the water, and is succeeded by the evolution of gases in the shape of bubbles, arising from the decomposition now actively at work beneath. Great and constant care is now required that this proceeds not too far, and thus injure the quality of the fibrous portion; it needs constant watching, and removal so soon as the desired effect has been obtained. This is readily seen by the experienced eye, by the manner in which the fibre separates from the shove on breaking a portion of the straw. Great judgment is required in determining the proper time for drawing the flax from the steep; if the process has not been carried far enough, the fibre is coarse and only suited for rough goods; if it is carried too far, the fibre is weak and occasions a great loss upon the heckles. This process, though less tedious than the dew-retting, still requires a considerable time for its operation—in pools or tanks from 10 to 14 days are required; in streams, where the temperature is lower, from 14 to 21 days

are consumed. In both cases much depends upon the quality of the water, and upon the general temperature; any impurities, especially salts of lime and of iron, are very injurious; they retard the fermentation and affect the fibre.

These irregularities, both as regards time and effect, produced by the cold steeping, led to the consideration of another method, by which a regulated temperature could be obtained, and the time and risk of the old process avoided. The merit of practically employing heated water for this purpose is due to Schenck, who took out a patent for it in 1846, though the principle was not at all new, and had, indeed, been partially applied fo many centuries past.

The first rettery on this principle was established in Mayo, in 1848; now there are upwards of 20 at work in the different provinces of Ireland, besides several in England; consuming between 30,000 and 40,000 tons of straw annually. In this the principle of fermentation is the same as in the old process, but is now placed under the control of the operator, who can regulate the action of the steep according to the quantity of the flax, or the article he wishes to produce. An important saving in time is effected; from 72 hours for the fine qualities to 96 hours for the coarse only being required, instead of from 2 to 3 weeks by the old process; and a more regular and certain fibre is obtained.

The temperature of the steep is kept between 80° and 90°, and regulated at will by the attendant. Here, however, we have the same destructive fermentation at work, as in the ordinary steeping; under a certain control, it is true, but generating the same foul and offensive gases. These gaseous exhalations, which far and near stamp the unpleasant proximity of a rettery, have been examined by various chemists, and have been found to consist chiefly of carbonic acid and hydrogen in nearly equal parts, with combinations of both sulphur and phosphorus with hydrogen. The fermentation appears to be of a peculiar character, merely traces of acetic acid being found, while butyric acid is generated in large quantities. In fact, the fragrant butyric ether, so extensively used as a flavoring substance, especially in the preparation of "pine-apple rum," might readily be collected in considerable quantities from the stinking water of the steeping pools.

At the Belfast Meeting of the British Association last year, an interesting paper was read by Professor Allman (Trin. Coll., Dublin), "On the Development of the Fermentation Fungus in the Fluid of the Warm-Water Flax Steeps:" in which he gave the details of his examinations of the process of steeping by Schenck's patent. The various phases in the development of the minute organism constituting the

fermentation fungus were described, and which he found to be analagous with those noticed in the fermenting state of other albuminous liquids. By putting some of them into flax-vats where the fermentation was not commenced it is very much accelerated; and he suggested the question as to whether or not it would be advantageous to apply the principle practically to the process of steeping. In new vats it is always found that the fermentation is not set up so readily as in old ones, which may be accounted for by the fact that some of these cells formed previously, adhere to the wood, and thus act at once upon the fluid when placed in the vat. This suggestion of Prof. Allman has been adopted, and found to succeed. Some years ago a method of accelerating the steeping process was in operation on the Continent, where common *yeast* was employed, the flax being placed in shallow tanks and carefully watered.

In some comparative experiments which were undertaken by the Irish Flax-Improvement Society, in 1850, the following doubts as to the hot-water process were specially investigated, and reported upon:—

1st. That the yield of fibre would be less than by the ordinary method.

2d. That fibre so prepared would be weakened.

3d. That the linen made from it would not bleach properly.

In reference to the first objection, the Committee reported that their experiments showed that the uniformity of temperature had the effect of increasing the yield of fibre. In one experiment, conducted at Lisburn, by Mr. Davidson, 112 lbs. of flax-straw, after being steeped and dried in the usual way, gave 20 lbs. of scutched fibre; while 112 lbs. steeped by Schenck's process gave 24 lbs. In another 112 lbs. of straw, cold-steeped, gave 14 lbs. 5 oz. dressed fibre; whereas the same quantity of straw yielded, by the hot-water process, 17 lbs. $11\frac{1}{4}$ oz. The increased yield in the first experiment was 20 per cent., and in the second $23\frac{1}{2}$ per cent., in favor of Schenck's process. As respects the second objection, the result was equally favorable. In the first experiment, the flax steeped in the ordinary way spun 96 lea yarn, and that by Schenck's system to 101 lea yarn. In the second, the cold-steeped gave 60 lea, and the hot-steeped 70. The third objection was submitted to an extensive bleaching firm, whose evidence in favor of the hot-water process was very decided. The Committee concluded their report by stating their belief that all reasonable objections had been fairly and satisfactorily met.

Other experiments, on a large scale, confirm their opinion. In ten comparative experiments, made with nine different sorts of flax, it resulted that the aver-

age produce of 1200 lbs. of flax-straw gave 144 lbs of dressed fibre in the hot-steep, and only 118 lbs. when steeped in the old way.

Dr. Hodges, in a paper read at the British Association Meeting (1852), gave a statement, extracted from the returns of the Cregagh rettery (Schenck's patent), of the changes which 100 tons of flax undergo when treated by this process.

100 tons of dried flax-straw yield—

1st. By seeding, 33 tons of seed and husk; leaving of seeded flax 67 tons.

2d. By steeping, 67 tons of seeded flax, yield of steeped straw 39·5 tons.

3d. By scutching, 39·5 tons of steeped straw, yield of dressed flax 5·9 tons.

Of tow and pluckings 1·47 tons.

This process is so simple, and the advantages over the old method so manifest, both in respect to time, quantity, and quality of produce, that it is somewhat remarkable that, notwithstanding the knowledge which existed of the value of temperature in respect to fermentation, even in reference to flax itself, it has only quite recently been practically employed. In looking back we find that in 1787 great interest was excited in Ireland by a plan to immerse flax in scalding water—a large portion of the vegetable matter was extracted, and fermentation was more readily set up.

In India, the practice of partially steeping flax and other similar fibres in hot water has existed for many centuries past. According to Dr. Campbell, at Bencoolen the process followed is to steep the hemp in warm water, in which it is allowed to remain for two or three days. In the presidency of Bengal, at Rungpoor and other places, the same practice exists; which appears also to have been followed by the Malays for a long time past.*

An old German process, termed "Molkenrost," in which the flax is steeped in sour whey mixed with warm water, is well known to generate a quicker fermentation, and to produce the finer qualities of fibre. In this the advantages appear to be threefold: the temperature of the mixture is favorable to fermentation, which is assisted materially by the nitrogenized compound (the caseine) of the milk; while the solvent powers of the lactic acid probably aid generally in the disintegration of the straw and the more perfect separation of the fibre. The relation between temperature and fermentation was very clearly shown and described by Hermstaedt, whose experiments in reference to the chemical principles involved in steeping flax and hemp were conducted at the commencement of the present century.

Many plans have been devised for dissolving out

*See Jury Reports, Class 4, p. 96. Gt. Exhibition, 1851.

the azotized extractive matter of the straw by means of chemical solvents, both acids and alkalies, and thus doing away with the tedious and noxious process of steeping. Both weak acid or alkaline solutions appear to a certain extent to have this property. These are also rendered more effective by an increase of temperature. Recently, about two years since, the attention of the public was called to a process patented by M. Claussen, both in Europe and in the United States, in which an alkaline solution was employed for effecting the preparation of flax fibre in a peculiar manner. The attempt itself, however, to cottonize flax has been discovered to be really no novelty; inasmuch as, in 1775, Lady Moira prepared both flax and hemp fibre in the same manner; the detailed particulars of which are given in the Transactions of the Society of Arts for that year. Specimens of the "flax-cotton," and of the fabrics woven from it, are still preserved in the Museum of that Society, and are remarkable for their beauty and permanence of color. Previous to Lady Moira's experiments, which were conducted on a considerable scale, and only relinquished because she could not get any one to take the process up and continue the manufacture, the action of alkalies on flax fibre had been described by Lilljikreuses and Palmquist, who, in 1745, had made use of a solution of caustic potassa.

In 1777 Baron Meidingen proposed the use of alkaline solutions for the purpose of *cottonizing* flax, and in 1780 a factory was established at Berchtoldsdorf, near Vienna, for carrying this process into practical operation; and similar methods were also brought forward by Kreutzer in 1801, by Stadler and Haupfner in 1811, by Sokou in 1816, and subsequently by several others. At Berchtoldsdorf, not only was the flax fibre made use of for the preparation of "flax-cotton," but a good article was obtained from the tow and refuse fibre. And the same is said to have been done by Haag, near Presburg, in 1788, by Göbelli in 1803, and Segalla in 1811.

From some cause or other, none of these various attempts seem to have been persevered in for any length of time. Either they failed when tested commercially, or the opposition of old-established interests and prejudices seem to have been too powerful for them; for Beckmann, who speaks of its introduction near Brunswick, states that the work-people determined not to use the new material; though at the same time, he observes, that excellent fustians were made from it, which could not be distinguished from those manufactured from the ordinary cotton. The similarity of this prepared flax to common cotton was remarked by Des Charmes, in 1799, and subsequently the subject received considerable attention from

Gay-Lussac, Berthollet, and others, whose investigations included the action of both hot solutions of acid and alkalies separately, and also by alternate immersions. Berthollet, in his Book on Dyeing, describes a process very similar to the one patented by M. Claussen, and which, from the curiosity of the coincidence, may perhaps not be found out of place if transferred to these pages. It runs as follows:—"A mode has been discovered of giving to the dressed hemp, and even to the tow, a division and fineness which qualify it for the same spinning processes as cotton; so that with this preparation alone, or mixed with cotton, stuffs may be made which have a much more considerable value than those of hemp in its natural state. It may likewise be mixed with silk, wool, and even hair; and the yarn resulting from these different mixtures furnishes, in its numberless variety, materials for new trials interesting to the arts and to general manufactures. The process consists of the following operations:—

"1. The fibres are covered with water, and left in it for three or four days, after which they are boiled in simple water.

"2. They are treated with a ley, and then passed into the oxygenated muriatic acid; operations which should be repeated alternately four times.

"3. The fibres are now transferred into a bath of

water, charged with $\frac{1}{100}$th of sulphuric acid, and left in it for half an hour.

"4. The fibres, when taken out of this bath, are washed very carefully, and plunged in soap water. They are then stretched out, without wringing, on hurdles, and left to dry."

Amongst other observations upon the process above described, Berthollet remarks that, "whether the finest flax or the coarsest hemp-tow be employed, filaments equal in their fineness and whiteness are obtained."

Giobert, in his "Bibliot. Ital.," vol. ii., gives some extended and exact observations on Berthollet's process, and he states them to be "the result of operations on a large scale, which have brought into the market cottony cloth, and bales of this hemp-cotton, which were not distinguishable from ordinary cotton;" from which it appears that great attention has been paid to the subject, and considerable expense incurred in the experiments. More recently, in 1842, M. Rouchon, of l'Ecole Polytechnique, at Paris, devised a method for preparing flax by means of immersions in a weak acid solution for a short period, and then placing it in a mass kept moist by occasional arrosions. These were repeated daily until the desired effect was produced. The flax was kept tied up in small bundles, and a man and a boy could attend to two tons per day. This process is still car-

ried on by Messrs. Bisson and Pradet de St. Charles. The use of chemical solvents has the advantage of effecting a great saving of time as compared with either the cold or hot process of steeping, and of being carried on without its unpleasant accompaniments. From *twelve to twenty-four hours are now sufficient*, instead of the *three or four days by the hot-water steep*, and *the two to three weeks by the ordinary processes.* The practice, however, is not likely to gain ground, as the ingredients are expensive, a portion of the products rendered useless, and the fibre liable to be injured unless proper care be taken.

We now come to the third division of the processes due to chemical agency, where *simple solvents*, as *water*, *either heated or in the shape of steam*, *is alone made use of.* This is a very important advance upon any of the old methods,—the tediousness and irregularity of the steeping process, whether cold or hot, with its noisome accompaniments are avoided,—no expensive chemicals are required,—the chance of injury to the fibre is lessened,—and the whole of the products of the operation are rendered valuable to the manufacturer. This method of treating flax was patented by Watts, of Glasgow, in the middle of last year, and was shortly afterwards carried into operation on a large scale at Belfast. Its simplicity and effectiveness were speedily recognised; and already

several other establishments are in progress in different parts of the country. The whole arrangements required, are inexpensive, and occupy but little space. The straw is placed in a steam-tight chamber, of a suitable size and shape, the top being formed by an iron tank containing cold water, and the lower end having a perforated false bottom at about 12 inches from the other. Steam at a low pressure is then blown from a boiler, through a pipe into the steaming chamber, and passing up through the straw, comes in contact with the iron top, by which it is condensed; then, trickling down the spikes, fixed there as points of dispersion, through the mass, it passes through the false bottom, carrying with it the extractive matter thus dissolved out of the straw, and is drawn off by a waste pipe into a vessel or tank below, in which it is preserved for use as a feeding substance. This is continued for from 10 to 12 hours. The straw is then removed, and is passed through four sets of smooth rollers, which squeeze out about 80 per cent. of the water, and at the same time crush the stems, breaking up the central woody core or "shove," and materially assisting its subsequent separation from the fibre. From these rollers it is carried to the drying-house, which is heated by steam-pipes from the boiler, and thence to the scutching frames, where the operation is performed more rapidly and efficiently than

when the flax is prepared by the ordinary method, owing to the thoroughly crushed state in which it comes from the rollers. The flax is then ready for market, having passed through the *whole process, from the raw material to the prepared fibre, in the short space of about 36 hours.*

The importance of this process to the flax interest generally was immediately recognised by the Flax Improvement Society of Ireland, and a committee of investigation appointed to institute "*a careful and extensive series of experiments, with a view to compare it, both in a practical and financial point of view, with the modes of hot and cold steeping generally practised.*" The Committee made their report on the 3d of November last. The experiments were personally superintended by the Committee, and flax of ordinary quality operated upon, of which 10 cwt. 1 qr. 21 lbs. was taken and placed in the steaming chamber, when it was submitted to the action of steam for about 11 hours. After steeping, wet rolling, and drying, it weighed 7 cwt. 0 qrs. 11 lbs., and on being scutched the yield was 187 lbs. of fine flax, and of scutching tow 12 lbs. 6½ oz. fine, and 35 lbs. 3 oz. coarse. The yield of fibre in the state of good flax was therefore at the rate of 18 lbs, per cwt. of straw, or 26¼ per cwt. of steeped and dried straw. The time occupied in the process up to scutching was

$24\frac{1}{4}$ hours; the scutching by 4 stands occupied 6 h. 16 m. In this statement, however, owing to some derangement in the drying apparatus, the time required for that is not included; but the Committee considered that 36 hours would include the time necessary in a well-organized establishment to convert flax straw into fibre for the spinner. The cost of all these operations in the experiment, leaving out the drying for the reasons stated, appeared to be under 10*l*. per ton of clean fibre for labor, exclusive of general expenses. The valuation of the samples varied from 56*l*. to 70*l*. per ton, according to the quality of the stricks of fibre sent; and the yield on the heckles was considered quite satisfactory. *The report throughout was very satisfactory.*

Here, then, we have a process which presents the following advantages over the ordinary methods:—

1. Great saving in time.
2. Economy of fibre.
3. Avoidance of any nuisance, and beneficial application of waste products.

Dr. Hodges, to whom the steep liquor was submitted for examination, found that one gallon, evaporated to dryness, gave—

Of organic matter,	- -	353·97 grains.
inorganic "	- -	161·49 "
Total extractive matter,		515·46 "

The organic matter afforded on analysis—

Of nitrogen, - - - - 17.79 grains.

The inorganic matter possessed the following composition :—

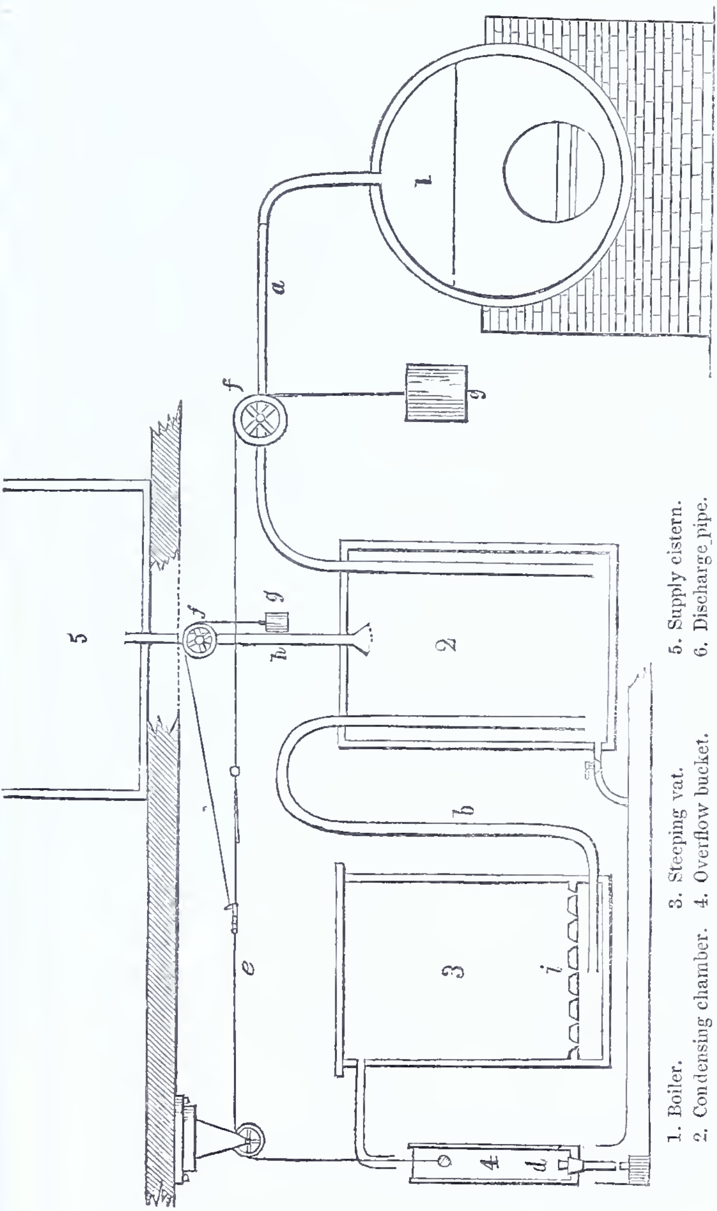
	Per cent.	Per gallon.
Potassa, - - - - -	27·17	44·63
Soda, - - - - -	3·18	5·12
Chloride of Sodium, - -	21·58	34·61
Lime, - - - - -	5·91	9·49
Magnesia, - - - -	4·60	7·40
Peroxide of iron, - - -	·83	1·33
Sulphuric acid, - - -	15·64	25·11
Phosphoric acid, - - -	5·66	9·01
Carbonic acid, - - -	12·43	19·96
Silica, - - - - -	3·00	4·83
	100·000	161·49

The taste and smell of the liquor very much resembled that of hay, and when poured over the crushed "bolls" or chaff, it was readily consumed by cows and pigs, who appeared to thrive on it. No purgative effect had been noticed, while its nutritive properties were estimated as fully equal to distillers' wash.

No sooner, however, had the spinners given their testimony in favor of Watts' fibre, than another process was patented by Buchanan, also of Glasgow, which appears to be an *improved application* of the *same principle* as Watts', for the solvent power is clearly not due to the steam as made use of by him,

but to the hot water occasioned by its condensation.

In this the steeping is effected by *repeated immersions* in a tank of heated water, arrangements being made by which the temperature is never allowed to exceed a certain degree—a point of great importance, both as regards the abstraction of the azotized extractive matter, and also the quality of fibre produced. It is well known that albuminous solutions, containing even a very small proportion of albumen (1 in 1000), coagulate at a temperature of 180°, and then become insoluble; and it is always considered that fibre is more or less injured if exposed beyond a certain high temperature. These two important points have been taken advantage of in Buchanan's process; the temperature of the steep liquor is kept within a certain range of temperature, and the operation, both as regards time and produce, more satisfactorily performed. The process is quite *automatic*, thus saving labor and the risks consequent upon carelessness; and the mechanical arrangements by which it is effected, are very simple and inexpensive. The accompanying diagram will, I hope, make the process clearly understood. The flax straw is placed in an open vessel (No. 3) termed the steeping vat, having a false bottom (*i*); a boiler (No. 1) generates the steam required; and between these two is placed a suitable vessel (No. 2), the condenser, of about the



1. Boiler.
2. Condensing chamber.
3. Steeping vat.
4. Overflow bucket.
5. Supply cistern.
6. Discharge pipe.

same capacity as No. 3, and communicating with that by the hot-water pipe (*b*), and with the boiler by the steam pipe (*a*). This centre vessel or condensing chamber is filled with water from the cistern (No. 5), and steam is then blown in from the boiler. When the latent heat of the steam is absorbed, and condensation no longer takes place, the hot water is driven over into the steeping vat, and completely immerses its contents. The overflow pipe (*c*) then conveys a portion into the bucket (No. 4), which, overpowering the balance weights (*gg*), descends, drawing the chain (*ee*), which, being attached to the pullies (*ff*) fixed on to the cocks of the steam-pipe (*a*), and of the condensing pipe (*h*), reverses their action by cutting off the steam and turning on a charge of cold water into the condenser. The steam in No. 2 is then rapidly condensed, and the liquor drawn back from the steep vat into which it had previously been forced. This completes the operation of immersion, which recommences immediately:—for as soon as the overflow bucket (No. 4) has reached a certain point in its descent, it strikes against a pin, having a screw adjustment, which causes the valve (*d*) at the bottom to open and discharge its contents into the discharge pipe (No. 6). The bucket, then relieved of its load, resumes its original position, the balance weights (*gg*) act on the pullies (*ff*), which

again reverse the cocks, cutting off the cold water sparge, and turning on the steam to No. 2. This is repeated as often as may be required.

So far as the experiments have gone, it has been found that by ten such immersions the whole of the coloring matter of the flax has been removed. These in practice would not occupy more than three or four hours. This, however, is subject to the test of the operations on a commercial scale which are now in progress in Scotland for carrying out the patent.*

By this process we have all the advantages obtained by Watts—economy of products—*increased economy of time, only four hours being required instead of twelve*—and, in addition, *great economy of labor*. Another great improvement is claimed by Buchanan, his method of drying the steeped straw preparatory to scutching. This is usually a tedious and costly process as regards labor and arrangements. The fibre, too, is to a certain extent liable to be injured by the necessary handling. The ordinary mode is to place the flax thinly spread between two wooden laths, which, when closed by means of hooks or rings over their ends, firmly hold the stems: about fifty-six of these are required for a cwt. of flax. They are

* The Patent for the United States will be carried out by the American Flax Company, of which Mr. Thomas Kimber, Jr., of Philadelphia, is the Managing Director, to whom all applications in reference to it should be made.

then carried to the drying shed and suspended from frames, where they remain exposed to the action of the air until they are dry. The time required depends on the weather—from three or four days to as many weeks. In Watts' process, where steam is available, the process of manipulation is the same, but the drying is effected in a heated chamber in a much shorter time. *Buchanan's method is entirely different.* He proposes to effect the desiccation in the same vat in which the flax was steeped, by means of *dry warm* air, which is driven through it in unlimited quantities, at a very little expense. The air is readily obtained in the desired state by causing it to pass through *porous earthenware* pipes set across the lower part of the chimney, which while heating the air, deprive it of its moisture. These communicate on the one side with a blower driven by the engine, and on the other side with a pipe which conveys the heated air to the lower part of the vat containing the flax to be dried. This is all the arrangement needed. The blower drives the air through the earthenware pipes; its temperature is there raised, and moisture abstracted, and entering the bottom of the steeping-vat, it comes in contact with the flax and passes through it, absorbing and carrying off the moisture, and leaving the flax in a perfectly dry state. It is then ready to be rolled and scutched. The

patentee's experiments induce him to believe that by this process the entire operation of converting the straw into dressed fibre may be effected in the working-day, or twelve hours; and, from the simple nature of the mechanical arrangements and of the materials required, a very moderate outlay would suffice for the formation of an establishment equal to the probable produce of a given district. The steeping process being entirely automatic, the cost of labor is very small indeed, and the whole expenses of the operation materially reduced.

In speaking of the treatment of the flax by these different methods, I have only referred to it in a dried state, harvested and treated in the usual way. It is not, however, necessary, that it should always be so: it is usually more convenient, it is true, where large quantities are to be operated upon; but where the quantity is small, and can be worked up at once, or at the commencement of the steeping season immediately following the harvest, it would appear from the following comparative experiments that steeping it when green is the most advantageous. M. Dufermont, cultivateur à Hem (departement du Nord), found that when the flax was used green, the steeping (by the old process) only required from six to seven days; and that six days grassing gave the flax a finer color than could be obtained by any other means. It was

dried and ready for scutching in three weeks ; whereas the ordinary time in the district averaged from 1 to 1½ year. He found also that it yielded 5 per cent. more fibre, which was worth fully 10 per cent. more money in the market. The flax was pulled before it was quite ripe, the seed-bolls removed by rippling, and the straw immediately placed in the pits. The seed, however, was reduced about 2 francs per hecto-litre in value. The details of the experiments he gives thus :*—

FIRST EXPERIMENT.

—	Value.	Original Weight.	Dried.	Steeped and Dried.	Scutched	Value per Kilom.	Value of Seed.	Gross Value.
	Francs.	Kilogs.	Kilogs.	Kilogs.	Kilogs	Fra'cs	Frac's	Francs.
Green flax.	222	4·030	..	826	191	1·70	27	357·70
Dried "	222	4·030	1·142	178	178	1·55	31	305·90
				Difference...........				45·80

SECOND EXPERIMENT

Green flax.	6·05	100	....	26·000	6·350	1·90	..	12·06
			Grammes.					
Dried "	6·05	100	30·250	22·500	5·500	1·65	..	9·07
				Difference............				2·99

The practice of steeping green is carried on to a large extent in the Waes district in Belgium.

Such is a sketch of the different methods of mak-

* Annales de l'Agric. Française, Mar. 1853.

ing this substance; their variety, both in principle and practical application, give ample evidence of the value which has always been attached to it in relation to the necessities or comforts of mankind.

Flax has ever occupied a prominent position in the agriculture of civilized countries. In Great Britain, we have seen that the government of early times encouraged its cultivation by special bounties. This policy was pursued up to a more recent period—nay, it even now is to a certain extent continued.*

Notwithstanding this encouragement, the supply has never been equal to the demand, and each year's imports show us the very large sums which England annually contributes to the farmers of other countries for an article of produce especially suited to her own, and which on all hands is now acknowledged to be, under fair management, a paying crop. Her imports of dressed fibre (flax and hemp) average, for the last ten years, 70,000 tons per annum; for 1851 they were 124,784 tons, showing an enormous increase; this at 40*l.* per ton, would amount to £4,991,360 sterling, or nearly 25 millions of dollars for these two articles, which could be entirely supplied to her by the United States.

Besides this large amount for fibre, she requires annually a supply of 650,000 quarters of linseed, to

* 1000*l.* per annum is granted to the Flax Improvement Society, by the Government, in accordance with the Act 11 and 12 Vic., cap. 115.

be used as seed or for crushing purposes—this requires an outlay of about 1,500,000*l.* sterling, which goes principally to Russia and the northern ports. This country at present does not supply her own demand for linseed oil, as large imports of seed are made every year from the same sources. The cake, however, the residuum of the pressed seed, so valuable as a feeding substance for cattle, is exported in considerable quantities to England, and forms a portion of the large supply which she draws annually from other countries. This averages about 75,000 tons, and amounts to about 500,000*l.* Thus a market already exists in Great Britain for all the surplus flax produce, whether in fibre, seed, or cake, which the United States will have to export for many years to come. The produce of 600,000 acres is required to supply the demand of the united kingdom;—while in Ireland, during the past year, only 136,000 acres were cultivated in flax, and probably not a fourth of that quantity in the rest of the kingdom.

Having brought my subject through the first period of its technical history, the preparation of the fibre, I may perhaps be permitted to say a few words on the state of the flax industry generally in Great Britain, and in those countries where the flax industry is most fully developed.

In England, in 1851, the Factory Inspectors' Re-

port gives the number of spindles at 265,568; in Scotland, at 303,125; and in Ireland at 500,000: forming a total number of 1,068,693.* In France we find the number of spindles to be about 350,000; the establishments being situated chiefly in the departments du Nord, Calvados, Finisterre, and Pas de Calais. In Belgium there are about 100,000 spindles in operation; the factories being at Ghent, Liège, Tournai, Malines, and Brussels. Holland possesses only one factory, of about 6000, in Friesland. Russia has two large factories, one at Alexandrofsky and the other at Moscow, together numbering about 50,000 spindles. Austria possesses eight factories, with about 30,000 spindles in operation. In the states of the Zollverein about 80,000 are estimated to be in use; and in Switzerland there are three or four small establishments, making between them from 8000 to 10,000 spindles. In the United States twelve small factories exist, having in operation about 15,000 spindles; these are situate in the States of New York, New Jersey, Pennsylvania, and Massachussets. The consumption of flax worked up by these spindles averages about 25 tons per 1000 spindles per annum for fine yarns, and about 30 to 50 tons for coarse yarns.

Now, reckoning the average cost of buildings, ma-

* The Report for 1852 shows a slight increase.

chinery, and motive power at 90*s.* per spindle throughout, it would appear that there is altogether a *fixed* capital of upwards of 8,000,000*l.* invested in the trade, of which sum 5,000,000*l.* belongs to Great Britain. Notwithstanding these large returns of machinery in operation at home and abroad, we find that the hand-spun yarn very far exceeds it in quantity, since throughout the Continent hand-spinning is still carried on to an enormous extent.

In England the manufacture of linen has increased from 45,000,000 yards in 1805 to 110,000,000 yards in 1850, notwithstanding the enormous development of the cotton industry during that interval. Her exports, too, testify to the position she occupies in foreign markets. In 1850 these amounted in the aggregate, for yarns, thread, small wares, and woven goods, to 4,828,994*l.*; in 1851 to 5,058,822*l.*; and in 1852 to 5,356,871*l.* Of the woven goods exported, the markets of the New World take the greatest proportion; those sent to the Eastern Hemisphere being of trifling amount in comparison. From returns recently published we find that 39,000,000 of persons in America consume annually more than 2 yards of her linen per head—equal to 1s. 3$\frac{5}{8}$*d.* sterling; in Canada the proportion is 1s. 6$\frac{1}{3}$*d.*, or nearly 20 per cent. more than in the United States; while 228,000,000 in Europe take but 1-38th part of a

yard per head. This remarkable difference does not arise so much from the consumption being proportionally less in the countries of the Old World as from the comparatively high duties which most of them maintain on the import of linen goods, and from the small disposition to use them in Asia and Africa, where cotton fabrics are almost exclusively used.

In conclusion, I would merely recapitulate the points which appear to me most worthy of your attention, and which I have endeavored to support by the evidence I have been able to lay before you. They are—

Firstly. That flax is not an exhausting crop; that its peculiar suitability to different soils and climates, the short period it occupies the soil, and the market returns of an average crop, render it a valuable addition to the ordinary rotations.

Secondly. That the recent improvements in the process of treating flax, whereby the fibre is prepared at an *immense saving both in time and labor*, *all nuisance avoided*, and the *waste products beneficially utilized*, offer great inducements for the establishment of small factories in suitable districts; thus directly encouraging an increased cultivation by insuring to the grower a ready and constant market for the produce.

Thirdly. That a large breadth of flax is annually sown in the United States of which the seed only i. rendered available as a market produce, the straw being only used to a very limited extent for the preparation of fibre, the rest remaining on the field or being carted home for rough litter.

Fourthly. That a very large sum, about 14,000,000 to 15,000,000 of dollars, is annually expended by the United States in the purchase of linen goods from Great Britain, which country is obliged to procure the raw material for their manufacture from other countries with which the United States has no commercial relations.

Fifthly. That it would appear expedient that the United States should utilize the large quantity of flax straw already grown, and increase her production sufficiently at all events, to supply the quantity in a manufactured state which she requires for the consumption of her own population.

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